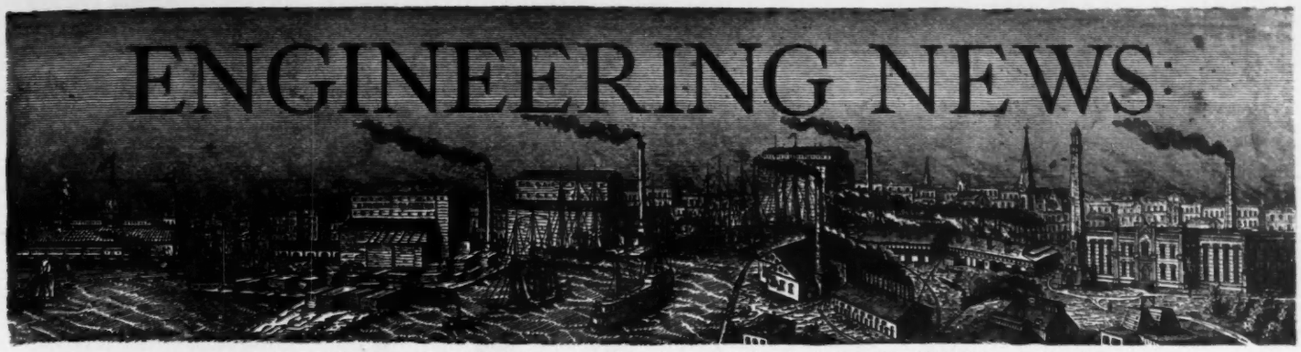
ENGINEERING NEWS:



A WEEKLY JOURNAL OF ENGINEERING, MINING, MANUFACTURES, AND GENERAL SCIENCE.

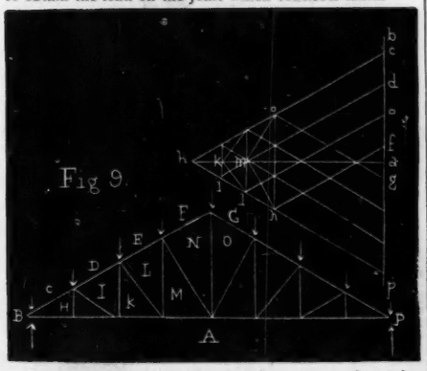
Vol. III.—No. 1 CHICAGO, SATURDAY, JANUARY 1, 1876. Subscription $2.12 per year Single copies, 6 cents

GRAPHICAL ANALYSIS OF ROOF TRUSSES.

BY CHAS. E. GREENE, A. M., PROF. OF CIVIL ENGINEERING, UNIVERSITY OF MICHIGAN.

III.

The truss represented by Fig. 9 is one well adapted for construction in timber, the verticals alone being made of iron, and it can be used for roofs of large span. In any actual case, before commencing to draw the diagram, assume an approximate value for the weight of the truss, add so much of the weight of the boards and slates, or other covering, as is supported by one truss, and divide this total weight by the number of parts, such as DI, or EL, in the two rafters. We thus obtain the weight which is supposed to act at each joint where two pieces of the rafter meet. The weight at each abutment joint will be half as much. If the rafter is not supported at equidistant points, divide the total load by the combined length of both rafters, to obtain the load per foot of rafter, then multiply the load per foot by the distance from the middle of one piece of the rafter to the middle of the next, to obtain the load on the joint which connects them.



Draw the vertical load line equal to the total weight and, commencing with *b c* as the load on B from one half of CH, space off the weights *c d*, *d e*, etc., in succession, closing at *p* with a half load as at *b*. The point of division, *a*, at the middle of *p b*, marks off the two supporting forces *p a* and *a b* which close the polygon of external forces.

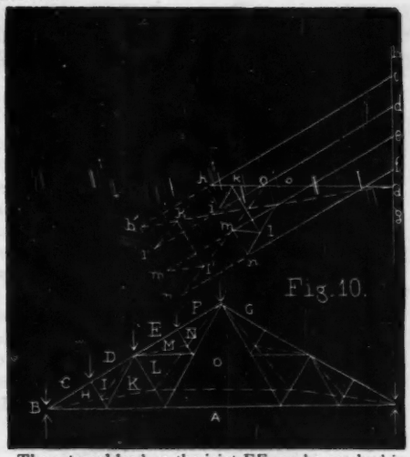
Commencing now at B, draw as heretofore directed, *a b c h a* for this joint. The order of these letters gives the directions of the forces on the joint B. Then, for the joint C D we have *h c d i k*; for H K we have *a h i k a*, for D E we have *k i d e l k*, etc. Observe that, by taking the joints in this order, first the one on the rafter and then the one below it on the tie, we have, in each case, only two unknown forces, out of, at some joints, five forces; and that it is expedient, when possible, first to pass over all the known forces at any joint, taking them in the order observed with the external forces when laying off the load line. The rest of the diagram presents no difficulty. After the stress on NO is obtained, the stress on O G is naturally the same as that on FN, and the diagram will begin to repeat itself inversely. It is therefore unnecessary to draw more than one half of the figure, although it has all been drawn here.

If we observe the kind of stress exerted on the joints by each piece, as we pass over the several polygons, we shall see that the rafter is in compression, as well as all of the inclined pieces, while the horizontal and vertical members are in tension.

Sometimes a vertical rod is introduced in the first triangle where the dotted line is drawn. It is evident that this rod will do no work, if all the load is assumed to be concentrated on the joints of the rafter, and we can find this out from the stress diagram as well; for, taking the joint below H in the figure, we have three pieces in equilibrium. We therefore begin at *a* and pass to *h* along the stress line lately determined for AH; then we are required to draw a vertical line and, from its extremity, a horizontal line to close on the point *a* from which we started; the vertical line can therefore have no length. All the work which can ever be done by this vertical rod is to keep the horizontal tie from sagging, by sustaining whatever small weight is found at its foot.

We lately saw, over a large coal shed, a truss intended to be of this type, where the builder, misled probably by the direction of the slope of the main braces of a Howe Truss bridge, had put his timber struts in the other diagonals of most of the trapezoids, their ends being apparently simply abutted at top and bottom. Thanks to a very heavy rafter of one continuous timber, the truss was still in place, but a heavy fall of snow would be likely to ruin it.

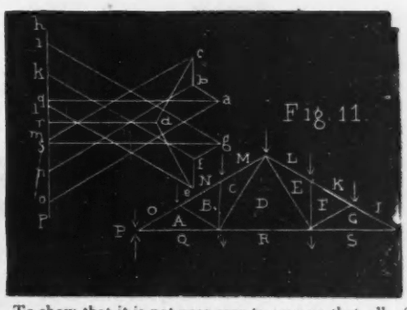
The skeleton of a truss which is often built in iron is given in Fig. 10. The loads at the several joints of the rafter are found by the method prescribed for the truss just treated. It will be unnecessary to dwell upon the manner of finding the stresses on the joints B, CD. and HK. The lines of stress for these joints will be *c h*, *h a*, *h i*, *a k*, *k i* and *i d*. If then we attempt to analyze the joint DE, we find that, with the external load, we have six forces in equilibrium, of which those along KL, LM, and ME are unknown. If we try the joint LA, we find four forces, three of which are also unknown. We are therefore obliged to seek some other way of determining one of the stresses.



The external load on the joint EF can be resolved into two components, one parallel to the rafter and the other perpendicular to the same. The component parallel to the rafter must pass down the piece EM, and the transverse component must be balanced by the resistance of the strut MN alone, for the rafter is jointed at EF. This compression on MN must be balanced, at its lower end, by the equal components, parallel to this strut, of the stresses in the two pieces ML and NO. Therefore the component, in a direction perpendicular to the rafter, of the stress in LM must be one half of the transverse component of the load on the joint EF. Besides, LM must naturally undergo the same stress with the symmetrical piece IK, and MN must have the same compression as III. Any one of these conditions adds enough to the data to enable the diagram for the joint DE to be drawn, and all of them must be fulfilled. Commencing then with *k i*, pass next over *i d*, then *d e*, then draw *e m*, parallel to EM, to such a point *m*, that (having drawn *m l* until its extremity *l* comes in the middle of what will be the space between *e m* and *f n*, or until *m l* equals in length *i k*), the line *l k* shall close on *k* whence we started. The ties and struts can be readily selected by the direction of movement over these lines in reference to the joint DE.

The remaining joints, when taken in the usual order of succession, offer no difficulty, and the other half of the diagram need not be added. The polygon which we have just traced, *k i d e m l k*, affords a good illustration of the rule that the forces which meet at a joint make a closed polygon in the stress diagram, and we may also see that the pieces which surround the space M, for instance, meet at the common point *m* in the diagram. The symmetry of the triangles *h i k* and *m n l*, and their resemblance to *k l o*, are worth noting.

Sometimes it is thought desirable to raise the tie AO, for the purpose of giving more height below the truss and to improve its appearance. The effect of such an alteration is very readily traced, and one can then judge how much change it will be expedient to make. Let it be proposed to raise the tie in the portion AO, and thus to introduce such changes in the other members that they shall take the positions of the dotted lines in Fig. 10, while the load remains the same. The line *a h*, for the joint B, will then become *a h'*, being prolonged until it meets *c h'*; next come *h' i'* and *i' d*; then we easily draw *i' k'*, *k' l'*, *l' m'*, *m' n'*, etc. The struts HI, KL, and MN are the only pieces in this half of the truss unaffected by the change; the amount of increase of the stresses in the others can be readily seen.



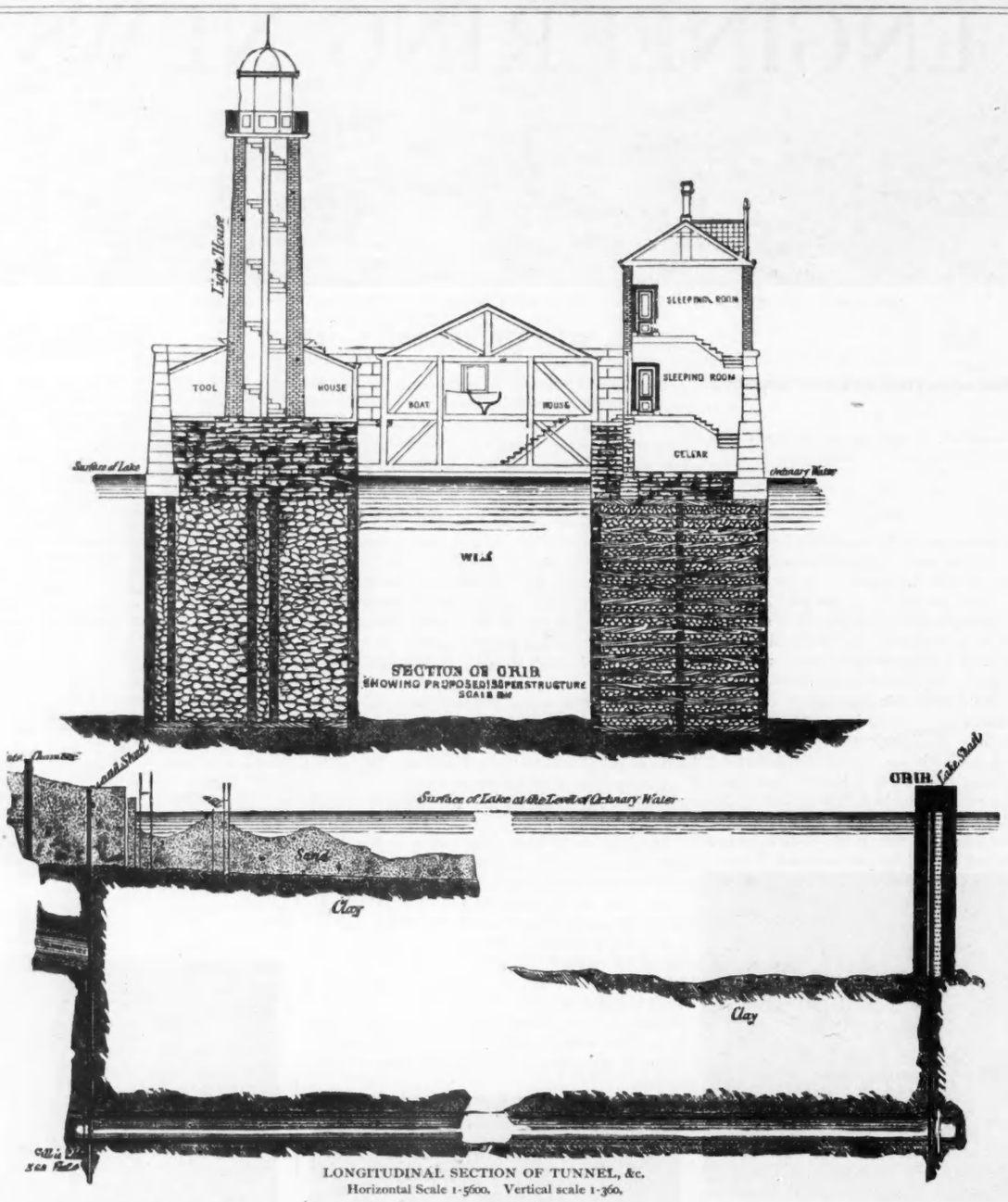
To show that it is not necessary to assume that all of the weight is concentrated on the rafters, let us discuss the truss in Fig. 11, supposing that the joints QR and RS carry their share of the weight of the pieces which touch these joints. Each supporting force will still be one half of the total load, but the two will no longer equally divide the load line between them, nor can the load line be at once measured off as equal to the total weight. Commencing, if convenient, with the extremity H of the truss, lay off *h i*, *i k*, *k l*, etc., ending with *o p*; lay off next the reaction, *p q*, equal to one half the total weight, acting upwards, than *q r* and *r s* downwards, and finally *s h*, upwards, for the other, supporting force, to close on *h*. The polygon of external forces, therefore, doubles back on itself, as it were, and *h p* is still only the load on the rafters.

The diagram can now be drawn, taking three joints on the rafter in succession before trying the joint QR, and, when taking that joint, remember that there is a load upon it. The loads on the horizontal tie cause the stresses on its three parts to be drawn on three separate lines, instead of being superimposed as in the figures before given.

LOGANSPORT, IND., DEC. 27th 1875.

EDITOR NEWS—Can you give me the address of some person who has had experience in the use of Nitro-Glycerine; we have to cross the Eel River 500 feet wide with 16 inch water pipe at a depth of 4½ feet in the bed rock, and will use it if it can be done with safety to lives and property.

Truly Yours, WALTER A. OSMER.
City Civil Engineer. Logansport, Ind.



LONGITUDINAL SECTION OF TUNNEL, &c.
Horizontal Scale 1-5600. Vertical scale 1-360.

THE CHICAGO WATER WORKS.

Description of the Lake Tunnel, No. 1

From the Eighth Annual Report of E. S. Chesbrough, City Engineer, for the year ending March 31, 1869.

In order to show the necessity for this structure which no one now doubts, but which was not so clearly seen when the subject of procuring a better supply was under discussion between the years 1860 and 1864, it will be proper to give a brief history of the

PREVIOUS MODES OF SUPPLY.

Although old maps show that the name of the present site of Chicago was called Chicagou more than a hundred years ago, yet the foundations of the city proper were not laid till 1833. From that date till 1840, when the population was about 4,500, no other supply than ordinary wells and cisterns existed, except what was carted from the lake. Then the old Hydraulic Works were erected by a private corporation. These consisted of an 18 inch inlet nearly 700 feet long from a crib in the lake to a well 15 feet deep, the inlet bending down nearly to the bottom; of pumping works on the lake shore, at the foot of Lake street; and of wooden supply pipes, of which latter, before the abandonment of the works, there were several miles, none of which exceeded 6 inches in diameter, and most of which were 2 and 3 inches. The greatest quantity ever supplied by these works is not accurately known. The engine and house have long since been removed, and the ground where the inlet was filled up. The Adams House occupies the site of the old works. The wooden pipes are frequently dug up in excavating for sewers and iron water pipes, and appear to be perfectly sound.

In 1851, when the population was about 35,000, a charter having been obtained by the city, the present works were commenced. Under the direction of the Board of Water Commissioners, the Pumping Works were located on the lake shore on the north side of Chicago river. In recommending this site Mr. Wm. J. McAlpine said:

"It is very questionable whether the small quantity of water which is discharged from the river would affect the quality of the water in the lake at a point one and a half miles south.

"From the consideration which I have given to the subject, I an of the opinion that there is no perceptible difference between the quality of the water in the lake above the pier, and at the place one and a half miles south of the river, on which the estimates have been predicated."

The works were put in operation February, 1854. They consisted of one reservoir, containing about half a million gallons, and 8¾ miles of iron pipe, besides the pumping works. The population at this time was about 70,000.

ACTION OF WATER COMMISSIONERS RELATIVE TO BETTER SUPPLY.

The increased growth of the city after that time, and the introduction of sewerage, together with the establishment of packing houses, distilleries, &c., caused such a change in the quantity of filth flowing into the lake that complaints began to be made of impurity and offensiveness occasionally in the supply from the pumping works. In 1860, one of the Water Commissioners, Mr. Edward Hamilton, proposed to sink a wrought iron pipe, 5 feet in diameter, one mile out into the lake to obtain a supply beyond the effect of the river. The project was referred to the Chief Engineer of the Board of Sewerage Commissioners to examine and report upon, with the request that "he also take under consideration and report on the matter of erecting additional pumping works in such locality as shall secure a supply of pure water."

The report made in compliance with the foregoing request did not recommend the immediate adoption of any plan, but discussed various projects. Among others, that of a tunnel was suggested; but it was thought best to defer the whole subject until further examination and analysis could be made, in the hope that much of the complaint against the water supply might prove imaginary.

What, however, was at first apparent only to the most sensitive organizations, soon grew evident to all, and in the course of two or three years more, the water supply became occasionally very offensive both to the taste and smell. A remedy for this state of things could no longer be neglected.

ACTION OF BOARD OF PUBLIC WORKS RELATIVE TO BETTER SUPPLY.

The Board of Public Works, which was created in 1861, discussed the various projects that had been suggested, and made experiments with filtering, which, however, they soon saw would not answer, The engineer of the Board, after much doubt and careful examination of the whole subject, became more inclined to the tunnel plan than any other, as combining greater directness to the nearest inexhaustible snpply of pure water, with permanency of structure and ease of maintenance. The possibility, and in the estimation of many, the great probability of meeting with insuperable difficulties, in the nature of the soil, or storms, or ice on the lake, was fully considered. One by one the objections appeared to be overcome, either by providing against them, or discovering that they had no real foundation. The plan, when so far worked out as to show how the tunnel might be constructed, was submitted to different engineers, among the number Col. J. D. Graham, U. S. Engineer, Mr. John B. Jervis, Capt. Wm. H. Swift, and L. H. Clarke, chief engineer Illinois Central R. R., all of whom expressed their belief in the practicability of the scheme. Benj. Carpenter, Esq., first President of the Board of Public Works, supported the plan warmly from the time it was explained to him; and the Hon. Wm. B. Ogden, though not a member of the Board, offered very early in the history of the project to advocate it publicly if it should be necessary. The other members of the first Board—Messrs. J. G. Gindele and F. Letz—though very cautious and somewhat doubtful at first, became satisfied with the general features of the plan. In the meanwhile, in consequence of legislative action, a new Board was chosen, consisting of the two last named gentlemen, Mr. O. J. Rose, and the Hon. F. C. Sherman, the mayor, who was *ex officio* a member. At the suggestion of Mr. Sherman, more thorough examinations of the soil, consisting of borings every 500 feet, were made. These fully confirmed what was previously inferred from the known character of the foundation underlying the northeastern portion of the city and extending out under the lake. The whole Board were now prepared to recommend the project to the City Council.

ACTION OF THE CITY COUNCIL RELATIVE TO TUNNEL PLAN.

A committee was appointed by the latter body to consider the subject. This committee consisted of Messrs. C. L. Woodman, J. A. Hahn, and F. C. Brown, aldermen; F. C. Sherman, mayor; and S. S. Hayes, comptroller; some of whom were known to have strong doubts with regard to the propriety of undertaking such a work; but the result of their investigations was a unanimous report in its favor. The City Council then passed the necessary ordinances, and the Board advertised the work for letting.

PREPARATIONS FOR LETTING THE WORK.

The opening of the proposals was looked to with great interest. as it was feared that no responsible parties would offer to take the work for less than millions instead of only about three hundred thousand dollars, the engineer's estimate; in which not only the public generally but the Board of Public Works themselves had no great confidence. The result was both surprising and gratifying to the Board. Seven bids were received ranging in amount from $239,548 to $1,056,000. Owing to failure to appear with sureties at the proper time, and to objectionable conditions, the two lowest bids were rejected.

On the 20th of October, 1863, after considerable inquiry relative to the ability and qualifications of the parties, and a visit of the city's legal adviser Benj. F. Ayer, Esq., to Harrisburgh, Pa., to ascertain the standing and pecuniary responsibilty of the sureties offered, a contract was entered into for the execution of the work with Messrs. J. J. Dull and James Gowen, of Pennsylvania. To this proceeding the City Council had given their authority by an ordinance dated the 5th of the same month.

OPPOSITION.

About this time the public press, which had previously almost unanimously spoken favorably of the project, turned almost as unanimously against it. This opposition gradually diminished but did not cease entirely till the work was nearly completed.

An injunction against the construction of the work, as likely not only to end in failure, but to involve the city in a useless debt of millions, was seriously talked of, though not publicly discussed.

On the evening before the date of the contract, an ordinance was submitted to the City Council. to repeal the authority previously given to the Board of Public Works to enter into contract for the tunnel. The preamble to this ordinance set forth that the construction of the proposed crib would be a permanent obstruction to navigation.

The Board of Public Works, to whom this subject was referred, stated in their answer that "The opinion of Mr. Ayer, submitted herewith, shows that the city has clearly the right to build the piers; that Congress, by its paramount authority, may declare the same unlawful structures, and authorize the courts to remove them; but that all previous court decisions establish that, before being ordered removed, the piers must first be shown to be serious obstructions to the lake navigation.

"The piers with their beacon lights, will, we think, be helps and not hindrances to navigation, — helps to show the sailor his position while in safe waters.

"The Board have, however, already taken steps to procure the sanction of Congress to the erection of the piers; but, if it comes to the worst,—that is, if the structures are declared unlawful, and the piers are proved to be serious obstructions to lake navigation, and the courts order the city to remove them,— the Board will remove them to such a depth below the surface of the lake that they cannot endanger navigation, as has been contemplated from the first,and as may be done at any rate."

The repealing ordinance was not passed.

OUTLINE OF THE PLAN.

The plan of the work as thus determined upon, consisted of a land shaft at the western and a lake shaft at the eastern extremity, to be permanent, and three intermediate lake shafts for expediting the construction, to be removed on the completion of the work. The tunnel proper to be two miles in length, beginning on the lake shore near the pumping works, and extending outward in an east north-easterly direction. The shafts to be protected by cribs, or hollow pentagonal breakwaters, from storms, vessels, and ice.

The horizontal diameter of the tunnel was fixed at five feet, and the vertical two inches greater, for convenience in drawing the centres during construction. This size was determined upon for two reason: *First*, it was sufficient to deliver a supply for one million of inhabitants at the rate of fifty gallons a day for each person, the average quantity used at that time. *Second*, experience in Europe had shown, that while it was possible to make small tunnels in the most troublesome ground, the attempts to make large ones had sometimes failed, and at others had been attended with enormous difficulties. This was particularly the case in works of the kind described by Minard in his *Cours de Construction*, pp. 284, 285, and in the earlier as well as later efforts to construct a tunnel under the Thames.

Although there was every reason to expect easy work here, there was a possibility of meeting with deposits of quicksand or other soft and wet material. In order to remove, as far as practicable, every doubt of the final success of the work, this small size was adopted, in the full conviction that whenever it should prove insufficient to supply the demand upon it, the population and wealth of the city would be abundantly able to construct another, and, if necessary, a larger one.

CONSTRUCTION OF THE WORK.

The work was commenced at the land shaft on the 17th of March, 1864, the delay since the date of the contract having been caused by waiting for the cast iron cylinders, which had been ordered by the Board, for the first thirty feet, instead of the brick shaft as originally intended.

These cylinders are 9 feet internal diameter, 1½ inches thick, and in three sections, each 10 feet long. The bottom of the lowest section has a cutting edge. The sections were united by internal flanges, bolts and rust joints. The top flange of the cylinder was fitted to receive an air lock, in case that should have proved necessary in the prosecution of the work.

It was intended originally to make the lining of the land shaft of brick clear to the top, but the Board feared trouble from the quicksand which extended down about 14 feet from the surface, and particularly as the inlet through which the city was supplied was not only in this quicksand, but very near the shaft. Owing to the want of suitable pumps, there was unexpected delay in sinking the cylinders, but as soon as the clay had been penetrated a few feet, all serious difficulty ended, and the remainder of the shaft was sunk to its proper depth through clay of various degrees of tenacity, from very soft near the top, to indurated near the bottom. Before reaching the bottom the contractors requested the Board to allow them to go deeper than the plan called for, in order to have a thicker roof under the bed of the lake; but on meeting with water and gas, they concluded that a greater depth would only bring them into greater difficulties, and were content to carry out the original design. The shaft was walled up 8 feet in diameter, with masonry 12 inches thick, to the bottom of the cast iron, the inside of which was laid with masonry to the top of the lowest section. At the bottom of the shaft there was a sump 6 feet deep below the bottom of the tunnel. This had to be emptied generally twice a day during the whole progress of the work, as the quantity of water discharged from a spring there continued very uniform.

From the bottom of the shaft a drift, at first only intended to be temporary, was made about 50 feet long, westward, with a chamber at the end with fixtures for mounting a transit. The regular tunnel work eastward was commenced May 26th, 1864.

Here much pains was taken to introduce a curved surface in the masonry between the shaft and upper side of the tunnel, and it was satisfactorily accomplished. The entrance to the tunnel was made 6 feet in diameter, and tapered down to 5 feet in a distance of twenty feet. The masonry on this portion was made of three shells of brick work, each four inches thick, with cement joints half an inch thick between. The rest of the tunnel proper was lined with two shells of brick work. It was intended at first to fill the cavities around the outside of the brick work with well tamped earth, but it was soon found impossible to get this done in a satisfactory manner. For this reason, solid masonry was almost immediately substituted for the tamped earth. The upper arch was built of a ribbed centre of boiler iron, which diminished the open space inside of the tunnel only 4¼ inches, and thus allowed the cars, which conveyed away the earth, to go up the face of the excavation, usually kept from ten to twenty feet ahead of the masonry. The iron centre was thirty inches long in the direction of the tunnel. About two feet in length of masonary was usually laid at a time, and as a rule it was found safe to strike the centre within fifteen minutes after the arch was keyed. At first it was supposed necessary to excavate nearly a foot above the top of the brickwork, in order to give the masons room to build the upper arch; but very soon it was found that they could build it perfectly well, generally, without making the excavation any larger than the space required for the brick work. This was done by driving the last four or five top courses of brick into well tempered cement morter first thrown into the cavity. The driving of the bricks effectually filled up the spaces which could not otherwise have been reached by hand. The ends of the masonry were left "toothing" and thus furnished a guide in driving the bricks on the upper arch. The lower arch was built by templets or patterns, as ordinary sewers are, and usually kept some six feet in advance of the upper arch, to allow of greater convenience in loading the cars with earth, which the miners had to keep at some distance behind them, and which the shovelers could not throw into the cars very well, when they stood under the brick work.

The excavation was, generally, through stiff blue clay, but with the irregularities of character peculiar to the drift. It very seldom required bracing when not left to support itself more than thirty-six hours. Sometimes sand pockets were met, and when those were over the upper arch, they would empty themselves partly, leaving cavities to be filled with masonry, but these were seldom of much importance. Sometimes small bodies of quicksand were encountered, but they occurred only in pockets and not in strata, and therefore gave no serious trouble. Sometimes the clay would be soft enough for a miner to run his arm into it but, with the exception of

(Continued on page 6.)

ENGINEERING NEWS.

SATURDAY JANUARY 1st, 1876.

TO OUR READERS.

We have no stereotyped salutatory remarks to offer. For nearly two years we have been groping our way, timidly and cautiously, along the boundaries of the great field of special journalism which we set out to explore. We are now about to take a new departure. From Montreal and Toronto in the Dominion; from the metropolitan cities of the East; from Port Eads on the Gulf; from the far away cities of the Pacific Coast, and from all parts of the interior states, has come the demand for a journal which would collect for the common benefit of the profession, the news of each week's progress in Engineering and general science, so far as it was attainable, and which would also afford a medium for the rapid intercommunication of new ideas, and the results of recent practice or discoveries by individual members of the profession, or of those interested in special scientific pursuits. In response to this demand we offer to our friends the WEEKLY ENGINEERING NEWS, in the full confidence that the generous support that has been accorded our more humble efforts thus far, will be continued in the future, and that in a comparatively short time we will be enabled to send each week to our subscibers an amount of information relating directly to their individual interests such as cannot be obtained from any other source, or for many times the price of our yearly subscription.

What we intend to do, has already been told and need not be repeated. But we cannot repeat too often that the success of our enterprise depends very largely upon the individual efforts of our friends in its behalf. We are not presuming to act the part of a teacher of Engineering nor have we space to throw away upon "hobbies." Our province is to collect, collate, illustrate, explain where possible, and to convey promptly and speedily, the special knowledge which we consider will be of most interest to our readers. This information must come principally from our readers themselves and we hope soon to see a steady stream of correspondence flowing into our sanctum, which will constitute the most truthful representation of the nation's progress in material development that can anywhere be found. The most neglected profession in the country at the present time is that of Engineering. Take up the directory of any city in the Union and look over the professional publications. There are Law Journals, Medical Journals, Religious Journals by scores, but when you come to look for a journal of Engineering you find that, with the exception of two monthly periodicals, there are none to be found. There are, to be sure, several very excellent class journals devoted to the interests of special branches of business, in which, now and then, some articles, of interest to Engineers, are to be found; but to obtain these it is necessary to be regular subscribers for several costly journals; something which Engineers and scientific men are not always prepared to do.

The most valuable papers on Engineering subjects in this country are published each month by the American Society of Civil Engineers, and the Civil Engineers Club of the Northwest. Those read before the former society are obtainable only by members and exchange journals; those of the latter society are published in ENGINEERING NEWS, and so are accessible to Engineers everywhere. Books also are very expensive and only those engineers who have large salaries and a permanent place of residence can indulge in the luxury of owning a library of any size. And yet, Engineers—those old in practice, and those just starting out for themselves—need to have their minds frequently refreshed with new ideas, and with the knowledge that is only to be gained by the study of the actual practice of their fellow Engineers. These are the ones to whom ENGINEERING NEWS must always be a welcome visiter, and it is for such that we will spare no labor, nor reasonable expense to render our journal a valuable assistant at all times. In this connection we wish to be understood that we include the Land Surveyors of America. As a branch of Civil Engineering of primary importance, and as connected with the most vital interests of the whole nation, we propose to lend what influence we may possess, or may acquire, to giving to this branch of the profession its proper rank, and in this we earnestly request the assistance of the Surveyors themselves. There are many able men among them from whom we hope to receive such information as will show what the present practice of Surveying is, what are its leading defects, and how they may be remedied, together with suggestions as to the best means of improving the standard of qualifications for practice and for increasing the present very insufficient pecuniary compensation for services rendered.

The universality of inventive genius throughout this country has given to Mechanical Engineertng particular prominence and popularity. The construction of great manufacturing establishments and their after management, together with the construction of numerous other important Engineering Structures have required in the Engineer to whom the carrying out of designs have been intrusted, a familiarity with Mechanical processes and appliances that can only be gained by thorough workshop training, in connection with the higher education of the draughting room and mechanical laboratory.

Hitherto we have not paid much attention to this branch of the Engineering profession, but henceforth we shall endeavour to make its treatment a leading feature of our journal.

Our field of labor is too large to be described in detail; we leave our readers to draw their own conclusions as to its extent and importance from the hints we have given and trust they may, one and all, assist us in developing it.

A REVIEW OF ENGINEERING IN THE UNITED STATES FOR 1875.

The past year has been one of depression in business, the stagnation in all branches of trade and manufactures having perhaps been greater than during 1874. Many schemes for improvements have therefore languished, and there is less of note and novelty to record than usual. We will endeavor to mention some engineering works which occur to us, not making, by any means, an exhaustive catalogue.

Our contemparary, the *Railroad Gazette*, always presents us with very full statistics in regard to American railroads. Let it suffice us then to note that the added mileage to our railroad system is still less than for the preceeding year. Very few new roads have been in progress, and much of the increase comes from small branches, added tracks, and other extensions on old roads. The amount of new track has been 1300 miles, as against about 1900 miles in 1874, 3420 in 1873, and 6700 in 1872.

The New York and Canada Railroad, 114 miles in length, on the western shore of Lake Champlain, from White Hall to the Canada line, was opened Nov. 29. The Portland and Ogdensburgh R. R. made connection with the Boston, Concord and Montreal R. R. by laying its track through the Crawford Notch of the White Mountains, and was opened in August. A portion of the location, along the mountain slope, was one of exceptional difficulty, but was surmounted with a remarkably light amount of work by a grade of 116 ft.

The introduction of fast mail trains proves the existence, on lines over which they run, of first class rolling stock and excellent permanent way, things requisite for the maintenance of a speed never before attempted in this country for trips of any length.

The new grade of the Harlem Railway, from the Grand Central Depot to Harlem River, a distance of about 4 miles, was completely opened for trains in June. Arched brick tunnels, flat-top beam tunnels and open cuts alternate, as the level of the surface requires. The way in which the various problems were worked out and the difficulties overcome are well worth study. The Rapid Transit Commissioners of New York city have announced their conclusions with regard to the kind of structures to be built, and specify the several forms and modifications of elevated railway which will be required. The Greewich St. Elevated R'y has been extended to 86th St., and will be further extended to Great Central Depot. It is now constructed with plate girders, and wrought iron cluster columns on a brick foundation, at the line of the street curb.

Work was resumed in August on the East River Bridge. The Brooklyn pier is finished, height 271 feet above tide; the Brooklyn anchorage is almost ready for cable laying; the New York pier is up some 200 feet, and the anchorage is fairly under way. The New York Dock Improvement goes steadily forward. Concrete is here employed in large masses.

The excavation for the removal of the obstructions at Hell Gate, or Hallett's Point, is completed, and covers an area of 2¼ acres. The roof of rock, 10 ft. thick, is supported on some 172 columns, and holes are now being drilled in both roof and columns for charges of nitroglycerine. When loaded and connections made, the water will be let in and the mine fired.

A new tunnel under the Bergen Hill, New Jersey, 4500 ft. long, is being rapidly advanced. The Musconetcong Tunnel, on the Easton and Amboy R. R. in New Jersey, was completed in the early part of 1875, although the headings met Dec. 16, 1874. Its length is a little less than one mile. A very thorough paper upon it, containing a great deal of matter of interest to engineers, was read before the American Institute of Mining Engineers, and published in the *Engineering and Mining Journal*, as well as the *R. R. Gazette* last year.

The famous Wooden Portage Bridge, on the Erie Railway, over the Genesee Falls, was destroyed by fire and replaced by an iron one, 800 ft. long. A new iron bridge across the Missouri, at Atchison, Kansas, highway and railroad, was completed Aug. 4. It has a draw-span of 382 ft. and three fixed spans of 269 ft. each. As an example of rapid renewal we may cite the iron bridge at Port Jervis, on the Erie R'y. The former one having been destroyed by an ice freshet, March 16, the new one consisting of one span of 166 ft. and three spans of 156 ft., was ready for trains April 25. A new suspension bridge is under contract for the Monongahela River, near Pittsburg.

Capt. Eads, having contracted with the U. S. Govern ment to make a navigable channel for our largest vessels at the mouth of the Mississippi, commenced his work of improvement June 14. He is building two jetties, composed of a combination of willow mattresses and stone, guided to place by piling, a modification of methods long in use in Holland and elsewhere. The width between the jetties at their outer ends will be 1000 ft. The work has been pushed with vigor, its feasibility in this place has been demonstrated, and a manifest improvement has already been made.

The tunneling of the Detroit River is still mooted despite the abandonment of the work at Detroit. Soundings have been taken by the Canada Southern R'y, with favorable results, and plans have just been completed for a crossing at Grosse Isle. The bed of the river there is limestone; the length of the tunnel proper would be only ½ mile, or with approaches 1½ miles. This new road is doing a good business, with excellent prospects for the future.

The work of the U. S. Coast and Lake Surveys has made regular progress. Harbor and river improvements have been carried on at various points of our sea and lake coast. These consist largely of dredging and protection of channels, building of breakwaters, &c. The protection of the Falls of St. Anthony from prospective, speedy destruction has been vigorously carried on. The floor of timber packed with concrete, for the Sault St. Marie lock which was commenced in 1873, has been under construction. The lock will be 515 ft. long, 80 ft. wide in the chamber, 60 ft. at the gates, and have 16 ft. of water at the mitre sills. The United States Engineers have been prosecuting their experiments the past year with torpedoes, as offensive as well as defensive weapons of war. They have also been engaged in another Isthmus Survey.

The Edgar Thomson Steel Co. (Limited) commenced operations near Pittsburg the first of September, They possess very complete Bessamer plant, and remarkable success, showing excellent engineering, has attended its operations from the start. The product for the first ten weeks was 3900 tons of steel. Natural gas has been introduced, and successfully applied, in some iron works at Erie and at Pittsburgh. It is brought, at the latter place, 19½ miles through a 6 in. pipe. Mr Reese of Pittsburgh, for cutting steel bars cold, makes use of a disc of soft iron, 42 inches in diameter, ⅜ in thick, running 5500 revolutions per minute.

In New York, a brick wall, 70 ft. high, about the same length, 16 in. thick on the base, and 12 in. at top, was moved 18 inches laterally. Compressed air has been tried as a motor for street railways. Some interesting experiments have taken place with a design for a single break railway. A new application has been found for the sand-blast in making the satin finish on plated ware and silver. [TO BE CONTINUED.]

Articles for publication should be written only on one side of the paper.

THE END OF THE SURVEYING SEASON.

With the arrival of the holidays the surveying season of 1875 may be considered as closed. A few surveys may be wanted from time to time through the winter, but the sum total of the professional business done by all the surveyors of the city between this time and March next will not suffice to pay the running expenses of the several offices. The past season has not been a profitable one for surveyors in this vicinity. Their income is derived almost entirely from the subdivision of land into city lots, and the survey of city lots for building purposes. Owing to the dullness prevailing in real estate matters the former branch of the business is not productive of much income, and the latter is distributed among so many offices that the best patronized of them all cannot count on even a fair return for the time spent and the expense incurred in the maintenance of an office and staff of assistants. Another feature still more discouraging than the lack of business has been the sad lack of even the first principles of honesty in many of the parties who have received the benefit of the surveyor's services. Surveyors are not generally called upon to work for very poor people, as it may be taken for granted that a man who has a city lot to be located has the means to pay the surveyor, and it is the experience of surveyors that no pay is so prompt and certain as among the class of single lot owners who have either already built or are preparing to build, and want the corners of their land designated. But since the panic of 1873 it has become the fashion in certain business circles to put forward the hard times as an excuse for the non-payment of any and every claim, in the hopes of staving off all, and of finally escaping the payment of a part, and it is now a matter of the commonest occurrence for men who stand high in business and social circles, and who would instantly resent the imputation of lying and dishonesty, to deliberately *perjure* themselves with an "affidavit of merits" for the purpose of evading a claim which a long suffering creditor has been obliged at last to bring before the court for collection. Very often a debtor is actually unable to pay, (a circumstance which does not justify perjury in the endeavor to gain time,) but such is not the usual case among those who employ surveyors, and so it has come about that these latter have not only to suffer from a lack of business, but also from the inability to collect what is due them from men who are abundantly able to pay the trifling amounts which ordinary surveys involve. They have spent their time, have advanced all the expenses incurred in the field and office, and having delivered up the necessary plats and maps find that they have to earn the money over again in following up their patron, and at last, wearied by the effort, do just what the latter wants done—consign the case to the oblivion of a Cook County Court.

We hope to see a law introduced ere long that will in some measure remedy this matter, and give to a surveyor at least an equal right with a mechanic or a merchant, allow him to have a prior lien on the premises surveyed until paid. Another remedy which we propose is to require pay in advance. An advertisement in a daily paper must be paid for in advance. An engraver or a lithographer requires a certain proportion of the contract price to be paid in advance, and the balance as the work progresses. Other trades exact the same terms, and we hope to see it become a rule among surveyors to insist on payment in advance and as the work proceeds. In case of non compliance it is a fair warning to go no farther. Of course, every surveyor has clients with whom he is well acquainted, for whom and with whom, it is a pleasure to do business, and with whom there is that perfect understanding that mutual confidence begets.

THE LAND SURVEYOR.

We beg leave to introduce to our friends in the surveying profession, Mr. B. F. Dorr of New London, Wisconsin, who will henceforth conduct this department of the NEWS. Our own time must be largely devoted to the business management of our journal, and that we might not neglect this very important branch of the profession, we have engaged the services of Mr. Dorr, who has had the advantage of an extensive and varied practice in several states, both in the East and West, of this country, and who, we are certain, is more conversant with the needs of his fellow surveyors than we are, who have had almost an exclusive city practice, and who therefore can not realize so readily the importance of various subjects in relation to the actual practice now in vogue throughout the country at large. The success of this department must of course rest with the surveyors themselves, who we trust will co-operate with us in making it at once valuable and interesting. Already several important points have been fully discussed and practically settled, and may very well be allowed to rest for the present. A fair proportion of our space will be allowed for any discussion of other matter that may have for its purpose the elevation of the professional standard and the securing a fuller recognition of the value of the services to the community of the surveying profession.

It is the intention of Mr. Dorr, we believe, to commence a series of articles on the "Practice of Land Surveying as followed in the United States," and we have no doubt that plenty of opportunity will be given for discussion as the series proceeds. It would be very strange were it otherwise.

Communications may be addressed as usual to the office of ENGINEERING NEWS, 168 Washington St. Chicago, Ills.

In assuming the duties devolving on the editor of this department of ENGINEERING NEWS, we do *not* assume to know very much more than our brother surveyors. Having had a large and varied experience in the business, we hope to be of some use to the less experienced members of the profession, and to aid in elevating the profession to the position to which its importance entitles it. All intelligent and thoughtful surveyors know, that surveying and the men who are practicing it, are not considered to be of any great importance to the community, as a general rule; and we grieve to say that in many cases there is good reason for this want of respect.

This department of the NEWS is designed to be a sort of Surveyors' Congress, and it is hoped it will become a continental congress; and that in discussing the various questions brought before us, we may all be greatly benefited. If surveying is to take the position in this country which it ought to occupy, leading surveyors—men who by study and practice have acquired good judgment—must take hold and lift it into its proper place. Contributions, suggestions, criticisms and questions are earnestly requested. Questions from beginners, or from persons of limited experience, in regard to difficulties which they find in practice, will receive considerate attention, and careful answers.

Having thus made our bow, allow us to quote Professor Gillespie, "Land Surveying is perhaps the oldest of the mathematical arts. Indeed, Geometry itself, as its name—'Land measuring'—implies, is said to have arisen from the efforts of the Egyptian sages to recover and to fix the land-marks annually swept away by the inundations of the Nile. The art is also one of the most important at the present day, as determining the *title* to *land*, the *foundation* of the *whole wealth* of the *world*. It is besides one of the most useful as a study, from its striking exemplifications of the practical bearings of mathematics." B. F. D.

Dominion News.

DRAINAGE WORKS, 1875.

The expenditure for drainage works completed during 1875 was $174,687.33. For this amount 142 miles of drains, containing 896,036 cubic yards were excavated, and 114,900 acres unwatered. This expenditure is now repayable to the Province by a rent-charge on the lands unwatered, at the rate of $7.61 per annum for 22 years, for each 100 expended, as provided by the Act 36 Vic, cap. 38.

The total expenditure on drainage works, surveys, and obligations on contracts for 1875, will stand as follows:

Expenditure on works completed and given to Assessors.	$174,687 73
Expenditure on works in hand, including obligations on contracts.	147,450 00
Cost of drainage surveys under 33d Vic., cap. 2.	25,798 16
Cost of drainage surveys under 36th Vic., cap. 38, to close of 1876	5,399 00
Total expenditures and obligations,	$353,226 89
Available for additions or contingencies,	10,135 45
Total available under 33d Vic., cap. and and 36 Vic., cap. 38	$363,362 34

ARTESIAN WELL.

An artesian well is being sunk by the government of Ontario, at the Asylum for the Insane at London. The well is now nearly 1900 feet deep. As London itself has no waterworks, and the municipal authorities are at a loss to determine how to obtain the necessary supply for the city, the sinking of the well by the government is watched with considerable interest, as in case of its success the city and neighboring villages would avail themselves of the same means.

SCUGOG RIVER.

During the past season the bed of the Scugog River was cleaned by dredging below and above the lock entrances, in the lock chamber, above and below the swing bridge south of Lindsay, in the cut at the point known as the Devil's Elbow, and a new channel was cut at the cross creeks, having a width of sixty feet, depth of eight feet, and a length of 1,500 feet, making a material improvement in a crooked and somewhat difficult part of the navigation of the river. The lockmaster reports the following transits through the lock during the season of navigation of 1875:—394 steamboats, 704 scows, and 325 cribs of various classes, of timber. These returns show a decrease from 1875 in the passage of steamboats and cribs, but an increase in the passage of scows.

BRIDGE, MUSKOKA FALLS.

The bridge at Muskoka Falls is now finished, and is a well-built, durable structure of three spans, the centre one a truss 82 feet in length, the entire length being 180 feet, with two approaches 70 feet in length, or 250 feet over all. The centre pier and abutments are built of stone quarried on the spot, and well laid. The piers will therefore be permanent, and the superstructure only will at any time require renewal.

ROYAL ALBERT BRIDGE.

The preliminary plans of this structure, which is to span the St. Lawrence River at Montreal, are being rapidly reduced to order so as to be presented to a meeting of New England and Western, and Canadian Railway men which will be called during the month of January ensuing, to take into consideration the means to be adopted for establishing the financial basis of the undertaking.

The Dominion Government is building a railway from the mouth of French River, Georgian Bay, Lake Huron, to the Ottawa River at Ottawa City, at which point it unites with the Quebec, Montreal, Ottawa and Occidental Railway, now being built by the Quebec Province. The Royal Albert Bridge is to connect these railways with the American system to the south.

It is also proposed to build the Ontario and Quebec Line from Ottawa City to Toronto passing through the central part of Ontario, at Toronto meeting with the Great Western and its western connections, and at Ottawa City with the Q. M. O. and Occidental, and so over the Royal Albert Bridge to Portland, Boston, New York and other points now reached only over the G. T. R., thus forming an independent and competition line to this latter railway.

The importance of this great undertaking is thus to be seen, and we will in future numbers of ENGINEERING NEWS endeavor to show the railway system of the Dominion and its connections, and the important position that the Royal Albert Bridge occupies in connection with it.

Charles Legge C. E., of Montreal, is the Engineer of the proposed bridge.

We commend to the careful study of our readers the article on the "Graphical Analysis of Roof Trusses" by Prof. Greene of Michigan University. The use of this method of analysis is now becoming very deservedly popular on account of its extreme simplicity and adaptation to practical use, and many men, eminent in science, in Europe and America, are bestowing a great deal of valuable time and labor on its development. Among these Prof. Greene stands prominent, and the literature of Engineering has already been enriched by a former contribution of his on the subject entitled "Graphical Method for the Analysis of Bridge Trusses," and published in book form by Van Nostrand of New York city. The present series of articles by Prof. Greene will number about twelve and will be published in ENGINEERING NEWS each week until completed. We hope our readers will at once make themselves familiar with the method of treating the subject so as to be able to follow easily each week the demonstrations presented.

Matters of general interest will only be answered through the columns of our journal.

requiring a little more "trimming" for the masonry, this gave no trouble. Sometimes boulders, weighing several hundred pounds, were met, and interfered a little with the regular progress of the work, but seldom more than a little.

The greatest and most dangerous difficulty met with was one that was not anticipated at first, and that was inflammable and explosive gas. Early in the progress of the work several accidents occurred from this cause, but fortunately without fatal results to the workmen, though there were several narrow escapes. Very soon the miners learned to detect the proximity of cavities containing this gas from the sound produced by striking over them with their picks. When a cavity was thus detected, it was bored into with a small auger, and the gas ignited as soon as it began to escape. In this way explosions were prevented, which otherwise took place when large bodies of gas were allowed to mix with the air. The explosions that did occur were slight in character, but left a body of flame in the upper part of the tunnel. At such times the miners fell with their faces to the ground, and thus escaped without any greater injury than singed beards and eyelashes, and blistered faces, except in the first severe case when a miner was badly burnt. At this time the gas kept the miners out of the tunnel three days.

[TO BE CONTINUED.]

Academy of Sciences.

The Academy of Sciences met Dec. 14th at the hall 263 Wabash avenue. After transacting the ordinary business, the Committee selected to prepare a suitable memorial on the death of Prof. I. A. Lapham, of Wisconsin, reported through their Chairman, Gov. William Bross, who read the following memorial, which was placed on record:

MR. PRESIDENT: At the last meeting of the Academy the undersigned were appointed a Committee to prepare a notice of the life and services of Increase Allen Lapham, who died of heart disease Sept. 14, 1875, at Milwaukee, Wis. Such a tribute is eminently due to Dr. Lapham, for he was one of the founders of this Academy, and always took a deep interest in its labors and its prosperity.

He was born at Palmyra, N. Y., on the 11th of March, 1811. His father, Increase Lapham, was a contractor on the Erie Canal and other public works, and to this circumstance is due the profession of an engineer, chosen as the life-work of the son. While engaged building the locks at Lockport, N. Y., the beautiful specimens of organic remains found in the rocks gave the youthful engineer his first lessons in geology, and fostered a habit of close observation which undoubtedly formed the basis of his great scientific success in after life.

In 1826 he was engaged on the Miami Canal, and in the fall of the same year accepted a position on the Louisville Canal, where he remained two years. Here he commenced making a collection of plants, and his interest in botanical studies was kept up through life. His herbariums embrace some 8000 specimens, made principally in Ohio and Wisconsin, with many obtained by exchange with scientists in Europe. His first scientific paper, "A Notice of the Louisville Canal and the Geology of the vicinity," was published in *Silliman's Journal of Science* in 1828. Prof. Silliman commented on it very favorably, and Dr. Lapham was at once recognized as a rising man by the scientists of the country. During his long and most useful life he published a great number of papers on various scientific subjects, embracing especially the geography, the topography, the minerology, the fauna, and flora of Wisconsin, wisely judging that in this way he could perform valuable service for his adopted State. They were in the main founded on original observations made as best he could while pursuing his profession as an engineer.

He was for three years—1830–1833—Assistant Engineer on the Ohio Canal, located at Portsmouth, and in April of the latter year was appointed Secretary of the Board of Canal Commissioners, and removed to Columbus. In 1835–6, he aided in the passage of the law for a geological survey of the State. On the 1st day of July, 1036, he settled is Milwaukee, making that city thereafter his permanent home. Wisconsin was then a part of Michigan, the organic law erecting the new Territory not taking effect till the 4th. He was born among the Society of Friends, and always adhered to the religion of his ancestors. Like them, he pursued the even tenor of his way in business matters, "avoiding," as he wrote to a near relative, "poverty on one hand and the burden of a superabundant wealth on the other." A large portion of his time and energies during his entire residence in Wisconsin were devoted to such studies and publications as would make known to the world the natural advantages of the State, and the value of his services in this direction in contributing to its wealth and population, to its physical development, and to the social and moral welfare of its people, can scarcely be over estimated.

Dr. Lapham was married at Marshall, Mich., Oct. 24, 1838, to Ann M. Alcott, whose decease he mourned on the 25th of February, 1863. Five children, three sons and two daughters, survive. His ancestry can be traced back through a regular line of descent to Devonshire, England, in 1635.

Among his varied attainments and the great number of scientific papers he published, it remains to specify briefly a few of the more valuable contributions he made to the wide domain of human knowledge.

His catalogue of the plants of Wisconsin is a standard authority on that subject. In 1855 he published a most valuable memoir in the Smithsonian Contributions to Science on the animal-shaped mounds of Wisconsin. It covers ninety-five quarto pages, and is illustrated by fifty-five plates. He made numerous and very careful observations on the rise and fall of the water in Lake Michigan at Milwaukee, by which the highest and the lowest stage of the water and the mean average became known. The facts proved to be important in varioas ways, and were used by the engineers of Chicago and Milwaukee, in establishing their systems of sewerage, and for water-pipes, and laying foundations for their works, and also by the lake survey in charge of Capt. George G. Meade in fixing a zero from which to make soundings. In 1849 he proved by a long series of observations that there was a lunar tide in Lake Michigan at Milwaukee amounting to about one-tenth of a foot. In 1863, the late Col. Graham, U. S. A., without any knowledge probably of Dr. Lapham's discovery, announced the presence of a lunar tide at this end of the lake, his observations making it considerably larger than those of Dr. Lapham.

The public may have already forgotten that they are indebted to Dr. Lapham for the Signal Service, or weather reports, a work that alone should secure for him the gratitude of the entire civilized world, and make his an honored name in every succeeeing age. The telegraph had long reported the presence and the effect of storms, and the idea of predicting them may have occurred to other scientists; but a member of this Academy first suggested the means of making the telegraph practically valuable in predicting them. In December, 1869, he sent to the Hon. Halbert E. Paine, then a member of Congress from Milwaukee, a memorial representing the duty and the necessity on the part of the Government to make an effort to prevent the loss of life and property on the great lakes; the possibility of predicting the occurrence of destructive storms, and how it could be done. The memorial was accompanied by a long list of disasters that had occurred upon the lakes that year. The facts presented to Congress by Dr. Lapham through Mr. Paine were the means of securing the adoption of measures for weather predictions, and it is now claimed that 86 per cent of them have proved correct. They have already become a prime necessity to the commerce of the lakes and the ocean, to agriculture, and in fact to the entire business of the country. He spent most of the winter of 1870–'71 in Chicago assisting in the organization of the Signal Service, and in making up the results of observations upon which the first "storm predictions" or probabilities were based. How much every sailor, ship-owner, and others engaged in the commerce of our great lakes, in that of our ocean coast-wise trade, farmers, and others who look to the "Probabilities" for a guide to their daily actions, are indebted to Dr. Lapham for these advantages, it would be impossible even to begin to estimate. Hundreds if not thousands of lives and millions of money have been saved by them, and their value will go on increasing to the end of time.

Dr. Lapham was eminently a self-made man. His life and eminent services show what careful observation and untiring industry can accomplish. His early education did not go beyond the common school, and yet in 1860 he received from Amherst College the honorary degree of LL. D., and had won a position among the very first scientists in this, and perhaps in any other country. He was a member of nearly all the scientific societies in this country and in Europe. His labors and his great success in life should stimulate a host of our young men to go and do likewise.

All of which is respectfully submitted.

WILLIAM BROSS,
E. ANDREWS,
GEORGE C. WALKER,
Committee.

Gov. Bross placed a paper in the hands of the President, written by Mr. J. F. Bailey, Marion, Ga., on the subject of "Meteors." The list of donations was then read, after which the Committee on Membership reported favorably on the application of Edward W. Nelson, and the gentleman was elected unanimously.

The lecturer of the evening, Judge Caton, of Ottawa, was then announced, and began his remarks on the

"KEINDEER OF AMERICA."

After referring briefly to the genus and species of the reindeer, the Judge said the feature which distinguished it from all other species of the deer family was that the female was furnished with antlers as well as the male. The antlers were cast every year, but the female retained them until after the birth of her young, by means of which the mother was enabled to protect them. The antlers of the male were larger, and used as weapens, but they were only retained during the fall and winter, while the female kept hers till May. Another peculiarity was the spreading foot, enabling it to pass over snows and marshy ground without sinking. It was also remarkable that the frog of the foot became absorbed in the fall, and wore away, leaving a sharp surface, which took hold of the ice, and gave the reindeer a more secure footing.

The reindeer lived in the extreme northern latitudes. The two species in the United States were the Woodland Caribou, or larger species, and the Barren Ground Caribou, about half as large. They were so named from the character of the portions of North America around Hudson's Bay, where they were mostly found. In winter the smaller species moved north, and in summer they moved south. The movements of the larger species were exactly opposite, and of course they met during the year, although it was a curious fact that they never intermingled or interbred, thus proving that they were distinct species.

In Norway they were often kept in herds of 10,000 or more, and, as they were used for drawing sledges, as pack animals, and as their milk was the life of the country, they proved the wealth of that frozen section. They were domesticated and used all through Northern Europe to the extremes of Siberia, in Asia, and even as far as Behring's Straits. In the East they were larger and were worked double, their owners frequently riding them. Their principal food without which they could exist but a few months, was lichens, or reindeer moss, and this was imported into all the zoological gardens of Europe where it was sought to domesticate the animals.

The reindeer had not been domesticated in America to a great extent, but the speaker thought experiments would prove the practicability of the plan. While they were naturally shy, and never became as gentle as American deer, were fond of baulking, overturning sledges, and causing trouble generally to their owners and the Lap milkmaids who tried to milk them, still the speaker thought their domestication would be attended with success, and the habits of domestication be made hereditary in time.

The Judge's remarks were illustrated with specimen skeletons, upon which the fur had been preserved, and with maps, and were heard with interest by all present. At their conclusion the Academy adjourned.

OUR HEADING.

The new heading to our paper is a representation of the entrance to Chicago River and Harbor, and was sketched from the top of the inner light house on the north pier. We have, however, taken the liberty to introduce Ward's Rolling Mills, or a part of them, at least, and the city Water Works building and tower. Our aim is not to give merely a representation of any particular part of the city, but to employ such a one as will illustrate as fully as possible the character of our journal, and in this we think we have accomplished the end sought for. The sketch was made by Mr. Fehmer, of the firm of Laing and Fehmer, architects of this city, and reproduced by the Photo-Engraving process by Messrs Bond & Chandler, Engravers, of this city.

Civil Engineers' Club of the Northwest.

ANNOUNCEMENT OF MEETING.

The January Club meeting will be held at the Sherman House, at 4:30 P. M., Tuesday, January 4th.

Paper by F. W. Clarke, "BELT RAILROAD PROJECTS IN CHICAGO."

The attention of members is called to the necessity of sending in their dues for the current year. Cards, and a copy of ENGINEERING NEWS have been sent regularly each month since the September meeting. It is possible that some of these have not been received on account of changes of location by some of the members, and it is therefore especially desired that a response to the cards which have been sent out be returned as soon as possible, to enable the Secretary to make out a correct list of the membership of the Club.

ENGINEERING NEWS will be sent to members of the Club without farther expense to them than the payment of the usual yearly dues. It is necessary therefore to obtain a complete list of the members with correct addresses so as to insure the sending of the paper each week.

L. P. MOREHOUSE,
Secretary.

Correspondents desiring a reply by letter, must enclose stamps to pay return postage. We cannot undertake to return rejected manuscript unless stamps are sent to prepay postage.

Railroad and Highway Bridge across Taunton Great River at Fall River, Mass., in process of construction, 1875, for the Old Colony Railroad by

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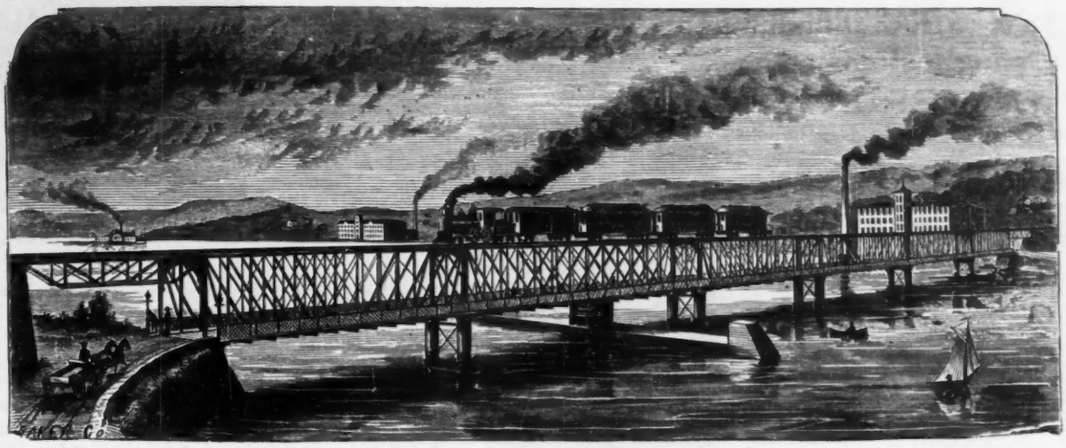

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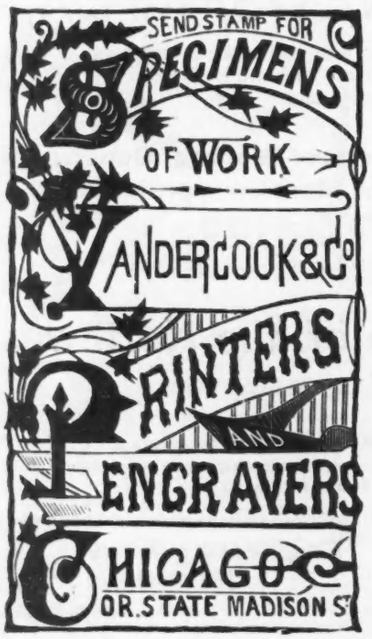

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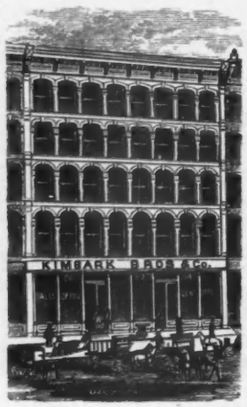

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TRADE MARK.

REG. JUNE 8TH 1871.

Without decreasing size of any part of our "Engineers' Transit" we have reduced the weight one-half. An ordinary Transit Telescope magnifies from 10 to 12 diameters, our new Transit Telescope (length 10¼ inches, shows objects erect and not inverted) magnifies 28 diameters and will read time on a watch-dial at 983 feet. For description of our new Mining Transit (weight 5¼ lbs.) and Plummet Lamp, see Van Nostrand's Engineering Magazine, June, 1875.

Extract from report of Committee of Civ. Engs. appointed by Franklin Inst. to examine H. & B.'s new Transit (Dec. 1871): "It exhibits several novelties of construction which, in the opinion of the committee, render it superior to those now in use, and in its opinion the deviations which they have made from the common styles of Transit are decided improvements."
JOHN C. TRAUTWINE, Chairman.

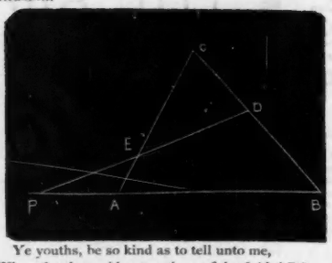
Descriptive and Illustrated Price List sent Post-paid, on Application.

We are in frequent receipt of letters of inquiry concerning the requirements for membership to the Civil Engineers' Club of the Northwest, together with the expenses attendant on membership. We are pleased to note this awakening of interest among Engineers and will take an early opportunity to publish the desired information. In the meantime parties wishing to learn about the society will please to communicate with the Secretary, L. P. Morehouse, Ill. Central R'y.

Mathematical Column.

PROBLEMS.

We have a poetical mathematician among our contributors, and we herewith present to our readers a specimen effusion.



21. Ye youths, be so kind as to tell unto me,
When the three sides are given of the field ABC
And a straight line be drawn through the points D and E
And produced to P in the range of AB—
The distance it crosses from C toward B
Is m times AE on the side AC,—
If the distance EC equals n times AP
What are the distances CD and AE?

S. P., Battle Creek, Mich.

22. In a plane triangle ABC, whose area is 4 acres, there are given A=40°; B=80°; C=60°: to find the sides of the triangle and two straight lines crossing each other at right angles.

23. Having the semi-circumference and minor axis of an ellipse given, to find the semi-major axis.

W. A. T., Hartford, Ct.

SOLUTIONS.

7, V. 2, p. 106. Seeing a number of answers to problem 7, I examined the question, and found by Geometry, that the stations W and E may be placed in four different positions and each fulfill the conditions of the question. The following are the results for the different positions.

	1st.	2d.	3d.	4th.
WE,	2591.2	1158.1	883.41	480.13
EO,	2215.68	990.26	755.38	410.55
WO,	1405.2	628.15	479.16	260 43

J. J., Whittlesey, O.

Mr. Editor—The conditions of Problem No. 5, requires that the given lines meet the nearest angles of a square; and require a side of that square.

T. T. in his strictures on my conclusions and without hinting that his solution is only approximate, says: "Therefore the given numbers do satisfy the conditions of the problem and one side of the square is 20.0736 feet."

Equations from (4) to (5) (NEWS page 107) give the approximate value of $S^2=402.9494169800402000040200004020000400200004$ and as this is a repetend it proves that the process will never end. Take square root and S= 20.07360000049991655. Therefore our conclusions are correct—*the given numbers do not satisfy the conditions of the problem*—A SQUARE—*and are absurd;* consequently the brother is mistaken.

JOHN NEWMAN.
Mansfield, Ohio.

Personal.

H. B. Ledyard is Chief Engineer of the Michigan Central Railroad.

Mr. H. F. Booth, Chief Engineer of the Chicago and Alton Railroad, who has been suffering from ill health for some time past, will spend the winter in southern California. The employes of the road have very generously made up a purse of $2,000 to defray his expenses.

Lieut. Col. C. C. Grant, of Hamilton, Ontario, is an enthusiastic geologist and has signified his friendship to the institutions of this city by sending to the Chicago University two cases of geological specimens. A son of Lieut. Grant is a resident of this city.

Prof. J. W. Clarke, a new accession to the corps of lecturers at the Chicago University, is an English geologist of eminence. He has paid particular attention of late years to the investigation of the cave remains found in England, and the subject of pre-glacial geology. The Professor will be absent from the city for some months on a lecturing tour.

WATER SUPPLY OF BALTIMORE.—Mr. J. McPherson of Pittsburgh, has been awarded the contract for the construction of the tunnel and reservoir for the Water Supply of Baltimore. The amount of the contract is about $4,500,000.

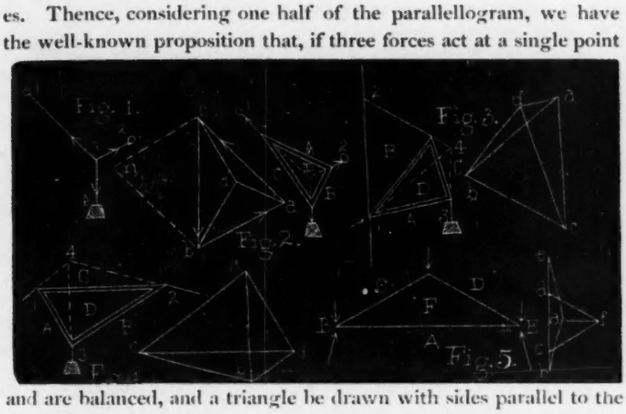
GRAPHICAL ANALYSIS OF ROOF TRUSSES.

BY CHAS E. GREENE, A. M., PROF. OF C. E., UNIV. OF MICH.

I.

It is proposed in this series of articles, to explain and illustrate a method for finding the stresses in all the pieces of a roof or other truss, under the action of a steady load, and to show how the wind or any oblique force alters the amount of the stresses arising from the weight. The diagrams, as here developed, are credited in England to Prof. Clerk-Maxwell, and the method is known by his name. But little previous knowledge of Mechanics will be required of the reader to understand the explanations, and we shall endeavor to make all points clear as we proceed.

Taking it for granted that, if two forces, acting at a common point, are represented by the two adjacent sides of a parallellogram, *c a* and *c n*, Fig. 2, their resultant will be equal to the diagonal *c b* of the figure, drawn from the same point,—a force equal to this resultant, and in the opposite direction, will balance the first two forces. Thence, considering one half of the parallellogram, we have the well-known proposition that, if three forces act at a single point



and are balanced, and a triangle be drawn with sides parallel to the three forces, these sides will be proportional in length, by a definite scale, to these forces. The forces will also be found to act in order round the triangle. If the magnitude of one force is known, the other two can be thus readily determined.

For example:—Let a known weight be suspended from the points 1 and 2, (Fig. 1,) by the chords 1-3, 3-2, and 3-4. Draw *c b* to a convenient scale, vertically, to represent the weight, by so many pounds to the inch. This line will, of course, be parallel to, and will equal the tension on 3-4. Draw *c a*, parallel to 1-3, and *b a* parallel to 3-2. Then will the triangle *c b a* represent the forces which act on the point 3, and they will be found to follow one another round the triangle, as shown by the arrows.

Suppose next, that a rigid, triangular frame is fastened on the cords of Fig. 1, so that, as shown by Fig. 2, the cords are attached at the vertices of the triangle, while their directions are undisturbed. Then it matters not if the portions of the cords within the triangle be cut away; equilibrium of this combination as a whole will exist so long as the directions of these cords, or forces external to the frame, meet, if prolonged, at a common point. We desire to find the forces, or stresses, exerted in the three pieces of this frame.

Before proceeding further, let us explain the notation which it is proposed to use, and which will be found very convenient when applied to more complex frames. In Fig. 2, write a letter in every space which is cut off from the rest of the figure by lines along which forces act. Thus D represents the space within the triangle, A the space limited by the external forces on 1 and 2, B the space between the pull on 2 and the line which carries the weight. Then let the piece of the frame or the force which lies between any two letters be called by those letters; thus, the upper bar of the triangle is A D, the right hand bar is B D, the cord to the point 1 is A C, that to the weight is C B, etc. In the triangle of forces external to the frame, *c b* will then be the vertical line of force to correspond with C B, *b a* the tension of the cord B A, and lastly *a c* the pull on 1. This method of notation was introduced by Mr. Bow, in his Economics of Construction.

Consider the left hand apex of the triangle. This point is in equilibrium under the action of three forces, viz., A C, C D, and A D; we know the direction and magnitude of A C, and the direction of the other two. The three forces at this joint must therefore be equal to the three sides of a triangle, as before. Notice that the external forces were taken in the order of the letters A C B, as shown by the arrows on the triangle *a c b*. Take then the forces at the left hand angle of the frame in the same order, and commence with the one fully known, or A C. Pass from *a* to *c*, because that is the direction of the action of this force on the joint under consideration. Next, from *c*, draw *c d* parallel to C D, prolonging it until a line from its extremity *d*, parallel to the piece D A, will strike *a*. The direction in which we passed, from *c* to *d*, and then to *a*, shows that C D and D A both pull on the joint where they meet.

Next take the lowest joint. Remembering again to take the three forces in equilibrium at this joint in the same order as the external forces were taken, and commencing with the first known one, we go, in the stress diagram, from *d* to *c*, because we have just found that the stress on the piece D C is a pull on this joint, next down *c b* in the direction in which the weight acts, and finally we draw, from *b*, *b d* parallel to the piece B D. This last line must close on the point *d*, or the construction has not been carefully made, and the direction in which we draw it, from *b* to *d*, shows that the piece B D exerts tension on the lowest joint. If the reader will run over the triangle for the right hand joint, he will see that the directions just given are complied with.

If we imagine that Fig. 2 is inverted, we shall have three thrusts for the external forces, the stress diagram will be inverted, and there will be compression on each piece of the frame.

In order to make these first principles more plain let us take another case. Suppose a triangular frame, (Fig. 3,) to rest against a wall by one angle, to have a weight suspended from the outer corner, and to be sustained by a cord attached to the third angle and secured to a point 2. Since the frame is at rest under the action of three external forces, and since the known direction of two of these forces, viz., A C and B C, will meet at 4, if prolonged, the thrust of the wall on the frame at 1 must have the direction of the line 1-4, otherwise rotation would take place. These three forces will then be found by the following construction:—Draw *a c* vertically, equal to the known weight acting *down* at the right hand corner; next, from *c*, a line parallel to the cord and force C B, and prolong it until, from its extremity *b*, a line may be drawn, parallel to B A, to strike *a*. As we went from *c* to *b*, and then to *a*, C B must pull on, and B A must thrust against, the frame.

To find the stresses on the pieces:—take whichever joint is most convenient, for instance, the one where the weight is attached; pass down *a c* for the external force, and then, observing the order in which the triangle of external forces was drawn, draw *c d* parallel to C D, and *d a* parallel to D A. C D will be a tie and D A a strut. Take next the joint at 1. Here the reaction as before ascertained, is *b a*; next, comes *a d*, the thrust of the piece A D against 1; and lastly, *d b*, parallel to D B, to close on *b*, the point of beginning, shows that D B also thrusts on the joint 1.

Once more, suppose that a triangular frame, (Fig. 4,) has a weight attached to its lowest angle, and that the other two points are supported by two inclined posts. The forces 1-4 and 2-4 must intersect 3-4 at the same point. Draw *a b* vertically, and equal to the given weight; draw *b c* parallel to 2-4 and *c a* parallel to 1-4. Note that *b c* and *c a* will both be thrusts. Next draw, for the lowest joint, after passing down *a b* for the weight, *b d* parallel to B D, and *d a* parallel to D A, thus finding that B D and D A, both pull on the joint A B. As in former cases, find *d c*, which is a compressive stress.

Enough examples have been given to show the first principles of this method. Since, in Mechanics, the polygon of forces follow,

naturally from the triangle of forces, and is simply a combination of several triangles, then, if we have several external forces or a number of pieces meeting at one joint, we follow the same rules. First, draw the polygon of external forces, taking them in regular succession round the frame, either to the left or right, as may seem convenient; next, take any joint and, commencing with the known force or forces, passing over each line in the direction required by the action of the particular force on the joint under consideration; treat the remaining pieces in the order in which the external forces were taken, and draw lines in the stress diagram parallel to these pieces. The direction in which the lines are drawn gives the action of the pieces on the joint. We dwell on this point at some length, because it must be clearly understood to enable one to rightly interpret his diagram.

Referring now to the figures which have been drawn, Prof. Maxwell calls the frame and the stress diagrams *reciprocal* figures, for the external forces, which must meet at one point, (unless parallel) in the frame diagram, make a triangle in the stress diagram, and the pieces which make the triangular frame have their stresses represented by the lines which meet at one point in the stress diagram. This same reciprocity will exist in more complex figures, and it is a valuable check, among many which we have, upon the accuracy of the construction.

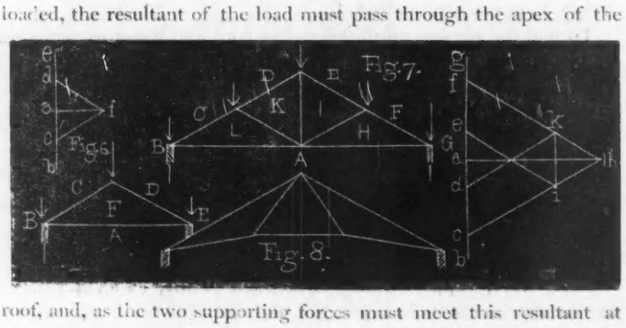
Note further, that where the point of intersection of the external forces falls within the triangular frame, the point of intersection of the stresses on that frame, in the stress diagram, falls within the triangle of external forces, and *vice versa*.

In our next paper we shall advance to the treatment of some simple roof trusses.

II.

Suppose that the roof represented in Fig. 5 has a certain load per foot over each rafter. Let the whole weight be denoted by W. It is evident that one-half of the load on the rafter C F will be supported by the joint B and one-half by the upper joint; the same will be true for the piece D F; therefore the joint at B will carry ¼ W, the upper joint ½ W, and the joint at E ¼ W. The additional stress produced on C F by the bending action of the load which it carries is not considered at this time, but must be noticed and allowed for separately. Lay off $e\,d$, or ¼ W, to represent the weight E D acting downward at the joint E, next $d\,c$ equal to ½ W, for the weight D C, and lastly $c\,b$ for the weight at B. Call $e\,b$ the *load line*.

Let the two reactions or supporting forces for the present be considered as a little inclined to the vertical, as shown by the arrows B A and A E. Since the truss is symmetrical and symmetrically loaded, the resultant of the load must pass through the apex of the



roof, and, as the two supporting forces must meet this resultant at one point, the two reactions must be equally inclined. Then, to complete the polygon of external forces:—as we have drawn $e\,d$, $d\,c$ and $c\,b$ in order, passing over the frame to the left,—draw, next $b\,a$, from the extremity b of the load line, parallel to the upward reaction B A, and lastly a line $a\,e$, parallel to the other reaction A E, to close on e, the point of beginning.

At the joint B we have equilibrium under the action of four forces, of which the two external ones are known. Therefore, taking them in the same order as in the case of the external forces, and commencing at c, pass over $c\,b$ and $b\,a$ in the direction of their actions; then draw $a\,f$ parallel to A F, denoting a pull on the joint B, and prolong it until $f\,c$, parallel to F C, will strike c, the point of beginning. F C will exert a thrust.

Passing next to the apex of the roof, we go down over the line $d\,e$ for the external force, thence up to f, and thence draw $f\,d$, parallel to F D. If this line does not close on d, the drawing has not been made with care. The stress $f\,d$ will show thrust on the apex from the rafter F D. As all the stresses are now determined we need not consider the remaining joint.

If the supporting forces had been more inclined from the vertical, the point a, of their meeting in the stress diagram, would have been nearer f, thus diminishing the tension on A F. The inclination might be so much increased that a would fall on f, when the piece A F would become unnecessary, the thrust of the rafters being balanced without it. If a fell to the right of f, $a\,f$ would be a thrust. If the two reactions are vertical, as will be the case when the roof truss is simply placed upon the wall, B A and A E, Fig. 6, will each be ½ W, and the point a will be therefore found at the middle of $e\,b$. The polygon of external forces has closed up and become a straight line, but, in the analysis, it must still be used. Thus we have $e\,d + d\,c + c\,b$ for the weights at the joints, and $b\,a + a\,e$ for the reactions.

The explanation used when the stress diagram of Fig. 5 was constructed will apply equally well to this one.

The reader will find it very useful, when drawing a diagram for himself, to represent different kinds of stress by lines of different colors; thus lines denoting tension may be drawn with red and compression lines with black ink.

The same method of analysis will next be applied to the truss of Fig. 7. Here the rafters are supported at points midway between their extremities. Each point of junction of two or more pieces is considered a joint, around which the pieces would be free to turn were they not restrained by their connections with other points. Whatever stiffness the joint may possess from friction between its parts, or from a continuity of a piece, such as a rafter, through the joint, is not taken into account, and may add somewhat to the strength of the truss.

Mr. Unwin in his excellent book on "Iron Bridges and Roofs," treats the rafter as a beam continuous over several supports, and determines the distribution of the load upon the several joints by this hypothesis. But, that such an analysis may be true, it is necessary that all the points at which the rafter is supported shall remain in a perfectly straight line. As this position cannot be realized, a distribution of the load between any two joints of the rafter proportionally to its distance from each, in accordance with the principle of the lever, will best represent the case. A different distribution of the load, however, if one prefers it, will only require a corresponding division of the load line.

In the truss just taken up, therefore, half of the load on C L will be carried at the lower angle and be represented by the arrow B C; the other half, as well as half the load on D K will make the force C D, and so on, three of the joints carrying each one quarter of the whole load, and the two others one-eighth each. On a vertical line lay off $g\,f = ⅛$ W, $f\,e = e\,d = d\,c = ¼$ W, and $c\,b = ⅛$ W; then, $b\,a = a\,g = ½$ W, the two supporting forces. Now, for the joint B, $c\,b$ = load, $b\,a$ = supporting force; then draw $a\,l$ parallel to A L and $l\,c$ parallel to L C; $a\,l$ is tension and $l\,c$ compression. At the joint C D, the load is $d\,c$, the stress just determined on C L is $c\,l$: then draw $l\,k$ parallel to L K, and $k\,d$ parallel to K D, to close on d. There is compression on L K and compression on K D. Passing next to the joint D E, $e\,d$ is the load, $d\,k$ the thrust of D K on this joint, $k\,i$ the tension on K I, and $i\,e$, to close on e, is the compression on I E. Take next the joint in the middle on the lower tie; we have $i\,k$, then $k\,l$, and next $l\,a$, the last of the known stresses. The next piece to which we come is A H; as we have just arrived at a we must pass back horizontally until a line from h parallel to H I will close on i, the point from which we started. The remaining line $h\,f$ is easily determined by taking either the joint E F or the one near G.

It will be noticed that, since the truss is symmetrically made and loaded, the stress diagram is symmetrical; $k\,i$ must be bisected by $a\,l$; $d\,k$ and $e\,i$ must intersect on $a\,l$. Attention to such points ensures the accuracy of the drawing.

It is impracticable to determine the stresses at any joint where more than two forces are unknown. In the present case we could not start with the joint C D or with D E; for we should know only the external force or load and have three unknown stresses to find; therefore our quadrilateral, having one side known, might have the other sides of any length, while they were still parallel to the original pieces of the frame. By taking the joints in the order just observed this difficulty was not met with. When, in some cases, we find three or more apparently unknown forces at a joint we may have some knowledge of the proportion which exists between one or more of them and a known force, and can thus determine the proper length of the line in the stress diagram. An example of such a case will be given soon.

We now submit a truss, Fig. 8, which the reader is advised to analyze for himself, as a test whether the principles thus far explained are clearly understood.